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Bio-Inspired Implant with Functions of Piezoelectric Stimulus for Antibacterial Effect †

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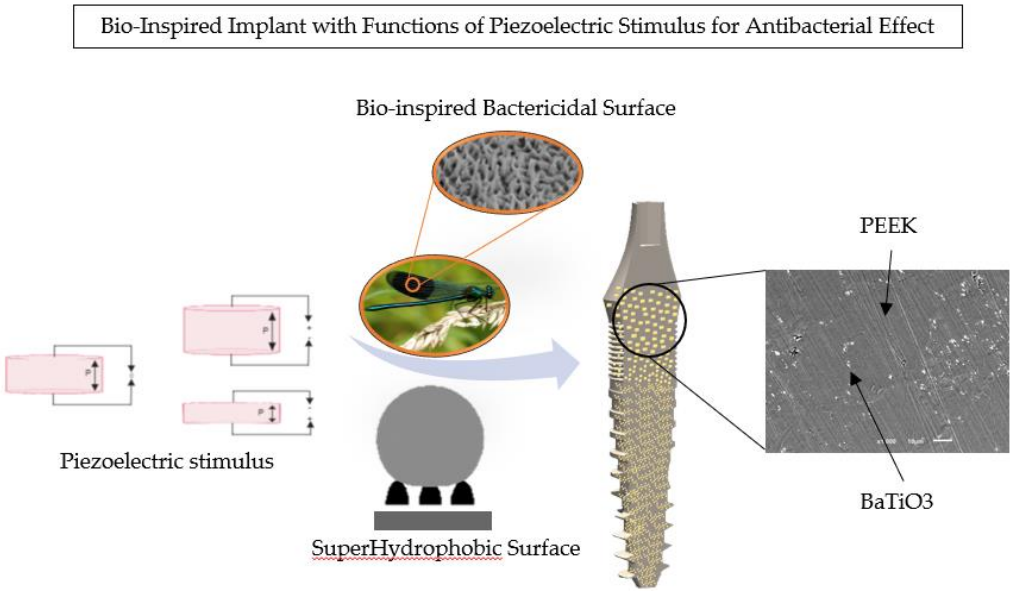

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Health care associated infections remain a worldwide devastating problem. Antibiotic bacterial resistance is becoming more widespread due to healthcare and agriculture antibiotics excessive use [1]. Nowadays, 700000 human lives are taken each year due to antimicrobial resistant infections and, it is estimated an alarming number of 10 million deaths by 2050 [1]. When focusing to implant materials, this emergence is even more accentuated. Considering a normal bone resorption of 0.19 ± 0.39 mm per year and consecutive biofilm formation in the generated gap [2], that could lead to an implant surrounding tissues inflammation and consecutive implant loss [3]. Dental implants present a 26.6% failure after 20-year and more than 600000 knee implants replacements in U.S. per year with a $9 billion cost. Current solutions are focused on preventing the biofilm formation with chemical surface coatings (antibiotics) that kill the bacteria once arrive on the surface, emerging even more the multi-drug resistant strains of infectious diseases [4]. Recent works presented solutions for bacterial adhesion with material surface topographical modification targeting superhydrophobicity (anti-biofouling effects). However, this approach is critical in water-immersed conditions [1]. The present research is focused on designing, producing, and characterizing a natural and non-antibiotic solution of a bio-inspired material with antibacterial functions, mimicking insect bactericidal surfaces, with the resource to a nanostructured contact killing mechanism. Additionally, a novel

approach of piezoelectric surface potentials for biofilm formation is used [5]. Barium titanate ($BaTiO_3$) is a lead-free piezoelectric (191pC/N) bioceramic without toxicological risk. This material presents a direct piezoelectric effect as a response to deformation. Different load conditions during chewing are exerted in the implants, leading to an autosufficient piezoelectric stimulation. Surface potentials are directly related to bacterial adhesion inhibition, and to change the bacteria lipid bilayer membrane [6]. The permeability increases leading to cell membrane penetration and disruption, with consequently bacterial rupture [6]. In this sense, a composite with micro $BaTiO_3$ particles (1.3μm) and PEEK (due to his high biocompatibility, already proved implant material potential and non-metallic ion release) were produced (1 wt%). The composites were mixed, hot pressed and laser texturized to produce surface topography targeting superhydrophobicity with bioinspired nano microstructures for bacterial adhesion inhibition and/or disruption of cellular structure. The implant materials were additionally poled in a silicon oil bath to orientate the surface potential in engineered directions to achieve the pretended solution. The material surface potential presents a major influence on wettability. The different samples were characterized with wettability measurement, SEM and XRD analysis, in order to evaluate the piezoelectric phase material phase. Primary studies on piezoelectric materials bacterial adhesion were evaluated with Gram-positive (Staphylococcus Aureus) and Gram-negative (Pseudomonas Aeruginosa) bacteria with an effective adhesion reduction (compared with a bioinert material). The present solution can also be designed and engineered effectively non only for implant applications but also for exterior contact with skin. More than 280 million patients suffer from diabetes worldwide. It is estimated that 15-25% will develop diabetic foot ulceration (for example), which could lead to amputation cases. 85% of the amputation cases were preceded by microbial infection [7], improving even more the potential of this Bio-Inspired Material with Functions of Piezoelectric Stimulus for Antibacterial Effect.

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